What is claimed is:

1. Design methods and apparatuses of photodiodes with adaptive structures to achieve smooth and wavelength-selective photo-responses comprises the following:

(1) utilizing the way of signal summation to yield the uniform distribution of the photo-response to be beneficial to the simplification on the design of the back-end compensation circuits,

(2) determining the adequate values of the process parameters of the semiconductors to achieve the maximum photo-response as well as to acquire the photo-response with the peak value at a specific wavelength, and

(3) designing the photodiode with multiple PN junctions to provide multiple photo-responses without using color filters in cooperation with the adequate layout design of this photodiode.

2. The design methods and apparatuses of photodiodes with adaptive structures to achieve smooth and wavelength-selective photo-responses ~~is~~ as mentioned in claim 1, where the method (1) utilizes the way of signal summation to generate the uniform distribution of the photo-response of the photodiode to be beneficial to the simplification of design on the back-end color compensation circuits and this method (1) is described as follows:

(a) it is designed directly from the photo-sensing area of the photodiode-and by performing the layout design to construct photo-sensing areas, the area size is in reverse proportional to the photo-response of the photodiode and utilizing adequate photo-sensing areas of multiple photodiodes to obtain multiple photo-responses, these photo-responses are summed together to yield the smooth

distribution of the total photo-response in all sensed wavelengths;

(b) it is explored by using the back-end amplifiers where in order to make the photo-sensing areas of photodiodes be the same size each photodiode is connected to an amplifier, such design conforms the specification requirements that each gain of these amplifiers is in reverse proportional to the photo-responses where multiple photodiodes produce the photo-response signals, after being enlarged through the amplifiers, that are added to generate the smooth distribution of the total photo-response;

(c) by means of the schemes of (a) and (b), the size of the photo-sensing area and the gain of the back-end amplifier are to be calculated and determined such that the gain ratios of multiple photodiodes are the reciprocal of the corresponding size ratios to obtain the smooth distribution of the total photo-response.

3. The design methods and apparatuses are mentioned in claim 1 where the method (2) is to determine the optimized values of the process parameters of the semiconductors for smooth and wavelength-selective responses of the photodiodes comprises the following schemes:

(a) determine the value of the process parameters to obtain the maximum photo-responses where the photo-response can be represented by Eq. (3.1) and the list below are some parameters which are the major parameters that affect the photo-response, where WU represents the width from the lighted surface to the depletion region, WD represents the thickness of the unlighted semiconductor, and n and p represent the electron and hole doping concentrations, respectively, and if we want to obtain the maximum photo-response, Eq. (3.2) represents how to decide the values of the parameters and that is to say, the width of WU should be as near the width of the depletion region as possible, and the width of WD

should be as wide as possible, whereas the doping concentrations of n and p should be as low as possible in designing the photodiode and if we conforms such design criterion, the photo-response with maximum value is obtained.

$$R = f(WU, WD, n, p)_{V=0} \quad \text{......................} \quad (3.1)$$

$$R_{Max} = f(WU \rightarrow Depletion, WD \rightarrow Max, n \rightarrow Min, p \rightarrow Min)_{V=0} \ldots (3.2);$$

(b) determine the values of the process parameters to obtain the peak value of the photo-response at a specific wavelength where from Eq. (3.1) of the photo-response, take out the parameters of α and $\phi 0$, and replace them with the functions of wavelengths, next the other parameters are replaced with the functions of concentration where then after two replacements, we re-write the original equation of the photo-response to become the equation with only two variables of wavelength and concentration and if we want the peak value of the photo-response appearing at $\lambda 1$ where first we must make the differential operation toward λ of this equation, next replace λ with $\lambda 1$, and then solve such equation to make it equal to zero and the whole process could be explained as the following equations

$$R = f(\lambda, n, p, V) \quad \text{........................} (3.3)$$

$$\frac{\partial R}{\partial \lambda} = f'(\lambda, n, p, V) \quad \text{........................} (3.4)$$

$$f'(\lambda, n, p, V)_{\lambda=\lambda_1} = 0 \quad \text{....................} (3.5).$$

4. The design methods and apparatuses are mentioned in claim 1, where the method (3) of designing the color photodiodes without color filters is proposed by using the photodiode with multiple PN junctions and multiple switches to generate multiple photo-responses for sensing multiple colors where first the photodiode is developed with multiple PN junctions to provide enough sets of photo-responses as well as to make more variations for the photo-responses and

since the overall photo-responses for a photodiode is the summation of the photo-responses from all PN junctions, the proposed method is to separate and take out one from multiple sets of photo-responses by shorting the undesired PN junctions where the electron-hole pairs in the shorted junctions are to be generated and recombined again and again where the photo-currents contributed by such shorted junctions would be erased and where the other PN junctions without shorting can accumulate their photo-responses to generate the total photo-responses as demand and regarding to switches for the shorting operations, the layout of connecting each PN junction with a switch is designed and when the P and N layers are connected by using a conducting material, this PN junction becomes the shorting status and thus does not generate the photo-current and at such condition, the switch for this can be viewed as the "close" status where on the other hand, when the P and N layers are not connected by using a conducting material, this PN junction is the opening status and thereby yields the photo-current and the switch for this PN junction at such condition can be treated as the "open" state and by using the switches to determine which ones of multiple PN junctions are used, the unshorted PN junctions can generate the required total photo-responses to interpret a specific color and the photodiode with multiple PN junctions and multiple switches can sense multiple colors at different switching conditions.